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INFANT'S RECOGNITION MEMORY FOR SALIENT AND NONSALIENT DIMENSIONS OF VISUAL PATTERNS

by

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Abstract

This experiment was a test of whether infants' general dimensional preferences can be used to predict what infants remember on visual recognition memory tasks employing those dimensions. Twenty-one-week-old infants were given a preference test with a variable form and a variable color pattern. Each baby was subsequently given two recognition memory problems, one employing a novel color and the other a novel form on the test trials. On both problems, length of familiarization was either 20 or 30 sec. Infants preferred to look at the variable form pattern. Infants also looked longer at a novel form than at a novel color. Twenty sec of study was sufficient for form recognition; 30 sec was sufficient for form and color recognition. Possible process explanations for the experimental findings are discussed.

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I. Introduction

The early months of infancy are marked by rapid developments in visual behavior, especially visual selectivity. The types of stimulus features attended by the infant change systematically in the first year of life. A pattern which elicits little looking by 2-month-old infants may be preferentially fixated by 6-month-olds. During these early months visual recognition behavior also develops. Infants improve in their ability to remember subtle features of patterns. Of theoretical interest, therefore, is the relationship between visual preferences and visual memory in infants. The present study investigates this relationship with respect to the preference and retention of two well-studied dimensions of information, color and form.

Development and Meaning of Visual Preferences

The visual behavior of human infants is selective--they look more at some aspects of their environment than at others. A basic goal of early research on infant visual perception has been to identify stimulus characteristics that underlie this selectivity. One fundamental tool has been the visual preference paradigm. In this procedure, two pictures or patterns are presented simultaneously for a brief trial. Left-right positions of the two are counterbalanced across trials. A reliable differential fixation response indicates a "visual preference" in addition to discrimination between the two patterns. For example, a baby may show a longer duration of fixation to a

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red pattern when paired with a green one. If the patterns differ only along one stimulus dimension, hue, we can infer that the infant perceives the two colors.

A major theoretical issue has been the nature of processes underlying visual preferences (Fantz, Fagan, & Miranda, 1975, p.296). Are such processes reflective of sensory or cognitive capacities of the infant? To view visual preferences as determined by sensory capacities is to link perceptual development to neurological maturation. To view visual preferences as involved in early cognition is to stress the less automatic and more voluntary aspect of infant perception. These are alternative (but not necessarily competing) theoretical orientations. A major difference between these two perspectives might be the degree to which they can incorporate and predict other phenomena in early perception. The present study is an attempt to demonstrate how a cognitive interpretation of visual preferences might be used to predict what an infant remembers.

The early promise of the visual preference technique was that it provided a means to assess individual differences in selective attention, which was characterized as a cognitive function. Fantz and Nevis (1967) compared visual preference development in institution-reared and home-reared infants. Group differences were found primarily for attention to configurational variations, the home-reared group showing earlier or more marked changes. Another

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comparison of infants expected to differ in cognitive abilities involved Down's Syndrome (DS) and normal infants (summarized in Fantz et al., 1975). Fantz et al. concluded that differences between normal and Down's Syndrome infants tend to occur for stimulus variations that are important in adaptive intelligence (e.g., form). However, the study of individual differences provides only weak support for the view that age-related changes in visual preferences are related to cognition. The lags in preference behavior shown by the institution-reared and the Down's Syndrome infants may not reflect attentional or cognitive deficiencies but rather differences in sensory or neurological functioning relevant to visual development.

Greenberg (1971) provides another cognitive interpretation for visual preference development. He suggests that changes in preferences reflect the increasing complexity of information processing by the infant. This link between cognition and visual complexity was derived by Greenberg from Berlyne's (1960) theory. Berlyne suggested that attentional preferences for stimuli depend on relations between the informational complexity of the stimulus and the processing capabilities of the organism. According to this point of view, the infant is likely to prefer a level of complexity just beyond his present processing capabilities.

Greenberg's hypothesis is not easily tested, however. Definitions of complexity have differed greatly, and attempts to manipulate this variable have confounded

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physical parameters of patterns (Haith, 1978). For example, Fantz and Fagan (1975) independently manipulated size and number of squares--two dimensions often confounded in complexity research--and found both variables to influence attention in the first six months of life. Furthermore, not all definitions of complexity have yielded attentional preferences that agree with those obtained by Greenberg (Haith, Kessen, & Collins, 1969). Thus, neither the contrasting of group differences in cognitive potential nor the hypothesis of age-related increases in processing complexity provide a strong case that visual preferences reflect cognitive processes such as selective attention.

A more physiological viewpoint suggests that changes in visual preferences reflect maturation of the visual system (Bornstein, 1978; Bronson, 1974; Fantz & Fagan, 1975; Karmel & Maisel, 1975). Here, selective attention to stimulus features is characterized as reflexive or automatic--the infant is 'captured' by the stimulus. Changes in visual responsiveness result from either qualitative or quantitative developments in neurophysiological activity within the visual system.

In one controversial theoretical paper, Bronson (1974) regards shifts in visual preferences as qualitative, reflecting the emergence of what he calls the primary visual system. His characterization emphasizes neurological development. During the first month of infancy, visual responsiveness is controlled by the secondary visual system

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which mediates the automatic looking toward a peripheral stimulus. Foveal input, which is involved in feature detection and encoding of complex visual events, is undeveloped. According to Bronson, the emergence, in the second and third months, of foveal vision and the functioning of the more cortical primary visual system allow the infant to voluntarily direct attention and organize patterning.

In related empirical work, Karmel & Maisel (1975) have dealt specifically with the changes in neural activity that underly visual preference shifts. They found that infants show peak preferences for increasing levels of contour density with increasing age. This is explained by positing a decrease with age in receptive-field size of contour-detecting cells (Karmel & Maisel, 1975). Karmel's position has been undermined by the observation that contour-density is not a unitary dimension; amount of contour is confounded with number and size of pattern elements (Bornstein, 1978; Fantz et al., 1975).

Bornstein (1978) has also presented an explanation of visual preferences based on underlying neural activity. Within the dimensions of hue and orientation, those cues eliciting more looking are those producing greater amplitude evoked potentials. Thus, preferences are the automatic product of net neural activity. This predicts infants' preferences for saturated versus unsaturated hues, and orthogonal versus oblique orientations. Bornstein

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specifically refers to attention as a 'taxic mechanism', although one with relevance for later cognitive behaviors. Nonetheless, there are difficulties with this, as with any attempt to explain behavior in terms of quantitative measures of gross neural events. As Bornstein (1978) notes, the problems include inadequate understanding of the meaning of components of the evoked potential, and inadequate definitions of attention itself.

The debate as to the sentience involved in early visual selectivity focuses on the first two months of life. While our knowledge of development of the eye, visual pathways, and cortex during this time period remains incomplete, both physiological and behavioral evidence indicate that, by the fourth and fifth months of life, the visual system is relatively mature (Bronson, 1974; Kessen, Haith, & Salapatek, 1970, p. 349). The theoretical issue as to the relationship between visual preferences and cognition may be more readily addressed at this time, when questions as to more fundamental determinants of selectivity, such as acuity, are secondary. It is also at this point that the infant seems more capable of robust recognition memory, as indicated in a variety of paradigms and with a variety of complex stimuli (Cohen, 1976; Olson, 1976).

Empirically, it is clear that a different set of stimulus attributes gain importance after the neonatal period. Whereas in the early months preferences occur for prominent and visible patterns (large sizes with high

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contrasts), by 2-4 months of age looking is directed toward patterns varying in form, color, texture, or configuration (Fantz et al., 1975, p. 330-332). These preferences do not necessarily indicate the emergence of new discriminative capacities. For example, Fantz and his associates have investigated the developmental changes in preference curves for stimuli contrasting such dimensions as size and form, brightness and hue. At 55 weeks conceptional age, a pattern of six varied geometric figures was preferred to a pattern of six larger squares equated for amount of contour. At this same age, however, infants' preferences were equal for a pattern of ten circles of various bright colors paired with a pattern of ten black circles on white ground. Thus, at 4 months, variation in the form dimension seems to affect what the baby prefers to look at; variation in chroma does not. Yet several studies indicate that the 4-month-old infant can discriminate a variety of forms and colors.

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At this juncture, the relevance of visual preferences to early cognition can be addressed. Attention is a prerequisite for further processing. Information which is not readily attended may not be readily remembered. With reference to the preceding review, it seems possible that, since form variability <u>is</u> readily preferred, 4-5-month-old infants are more likely to remember forms than colors. Such a result would be consistent with the hypothesis that visual preferences are directly related to perceptual learning and retention. If, on the other hand, infants were to show

equivalent learning and retention of color and form information, then the visual preference for form might be better interpreted as reflecting a tropism of no consequence to memory.

Development and Meaning of Recognition Memory

The development of infant visual memory has been studied primarily within two paradigms, habituation and paired-comparison preference for novelty. Both involve the idea that differential responding to novelty and familiarity implies memory.

The study of infant habituation had its historical antecedents in the animal learning literature. The satiation of the reinforcing effects of novelty was one predecessor. An even closer link was with Sokolov's work on the orienting reflex, which occurs to the initial presentation of a novel stimulus. Sokolov's neuronal model of the orienting reflex was important in that it specified the association between habituation and memory. Early work on infant habituation was largely demonstrative (Cohen et al., 1979). It indicated that by 2-3 months of age looking time decreased across repeated presentations of a single visual stimulus. Furthermore, 3-month-old infants showed an increase in looking to a novel stimulus presented at the end of habituation (Cohen, 1976). This recovery indicated that the response decrement was not due to fatigue and that the baby can discriminate the novel and the habituated stimuli. Early efforts, however, failed to demonstrate habituation in

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infants prior to 10-12 weeks of age. More recently, Friedman (1975) has tested neonates with long exposure trials and a relative criterion for defining decrements. Results indicated that some alert newborns decrease visual fixation to repeated exposures of a checkerboard, and increase visual fixation with the introduction of a new pattern. In summary, the habituation paradigm provides a sensitive technique for assessing basic information-processing capacities of even very young infants.

An alternative to the habituation paradigm is the paired-comparison procedure. It differs from the former primarily in that the retention test presents the familiar and the novel stimuli simultaneously. Thus, it is a variation of the preference technique. Preference is induced by previous exposure, or familiarization, of one of the pair. Relatively longer looking to the novel stimulus implies recognition of the familiarized stimulus. The paired-comparison procedure also differs in that it does not require a decrement in looking to signal the end of familiarization, i.e., the storage of the stimulus in memory. Therefore, it is possible to use paired-comparison in brief procedures which test recognition by allowing the infant to choose what to look at. This technique has been particularly sensitive in the study of delayed recognition memory (Fagan, 1973). Despite its methodological flexibility, the paired-comparison procedure does not appear useful with very young infants. Prior to 10-12 weeks of age,

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preference for the novel member of paired patterns appears to be weak. At this age, habituation to a single pattern appears to be a more sensitive index of visual recognition memory.

The study of habituation and novelty preferences indicates that recognition memory is present in the young infant. During the first three months, however, recognition memory is difficult to demonstrate and easy to disrupt (Friedman, 1975). By 5-6 months of age, the picture is a much different one. That which the infant has seen is not easily forgotten. The robustness of visual recognition at this point is indicated by several findings. The infant requires only very brief study in order to discriminate between a novel and familiar pattern; as little as 10 sec of study suffices for immediate recognition of multidimensional stimuli (Cornell, 1979). Further, the infant shows long-term retention of information. Photographs of faces, for example, are recognized after a two-week delay (Fagan, 1973). Even when the infant fails to recognize a pattern, he is able to utilize his earlier experience to facilitate relearning of that stimulus (Cornell, 1979). Finally, infant visual recognition memory is not highly subject to interference. Forgetting due to interference occurs only in select, highly constrained conditions (Fagan, 1977). In summary, by 5-6 months of age, the interesting thing about the infant is not that he forgets, but that he remembers.

Theoretically, the infant's capacities for visual

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memory have been regarded as an interface between perception and cognition (Cohen, DeLoache, & Strauss, 1979; Fagan, 1975). In the analysis of underlying processes, theories of infant recognition memory have especially sought to characterize the encoding and retention of visual information (Jeffrey, 1976; Olson, 1976). For example, Jeffrey's serial habituation hypothesis proposes that processing of a stimulus configuration is governed by the salience of its features. Salience, as operationally defined, is the probability of an observing response occurring to the feature. Features which are highly salient will be processed before less salient cues and will be processed more thoroughly (Jeffrey, 1976). Thus, Jeffrey makes explicit the hypothetical relationship between perception and memory:

> If the organism has had sufficient experience with the stimulus complex in the past he will spend little time with it, if he has not, or if there is a salient novel element, additional processing will automatically occur. (Jeffrey, 1976, p. 294)

As Fagan (1977a) has noted, the empirical concerns derived from Jeffrey's ideas--what it is about a stimulus that the infant processes, and how this processing occurs--are subject to test by visual recognition paradigms. Already we have some ideas as to the dimensions that are remembered (Strauss & Cohen, 1980). However, very few investigators have considered the dimensional preferences that may occur

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with or affect selective memory.

The most extensive work testing Jeffrey's serial habituation hypothesis has been done by Miller (1972; Miller, Ryan, Sinnott, & Wilson, 1976). Four-month-old male infants were presented with the following sequence of stimuli, each for 20 sec: NNPPPNNSSSSSSSSPPPSN (Miller, 1972). N refers to a colored slide, P to a slide of a part of the stimulus, and S to the intact stimulus. Total preexposure fixation time to each of the parts defined salience order for the parts. Comparison of pre- and post-habituation looking showed reduced fixation of the most salient feature (part), and increased looking to the least salient feature. In a later study (Miller et al., 1976) employing this same procedure with 2-, 3-, and 4-month-old infants in a more complex design, similar evidence of serial habituation to stimulus features was obtained.

Lasky (1979) has pointed out that Miller's results do not provide unequivocal support for the serial habituation hypothesis. In fact, the same results would be predicted by regression to the mean. Lasky replicated Miller's experimental conditions. Two other groups received the same sequence of trials as did the experimental groups (i.e., NNPPPNNSSSSSSSSPPPSN). However, for these groups the P trials involved the features from one intact stimulus, while the S trials used a different stimulus. That is, the infants were habituated to a different pattern than that for which they had viewed the component features. The latter

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regression conditions produced the same pattern of results as the serial conditions. Therefore, it appears that an experimental design employing the same stimuli for tests of salience as well as habituation encounters problems of interpretation.

The present study is a futher test of Jeffrey's hypotheses. That is, it is proposed that the infant is selective in what he processes, that such selectivity is guided (in part) by feature salience, and that there exist boundary conditions under which selectivity affects memory. The present study, however, differed from earlier tests of Jeffrey's hypotheses in several respects. In the present study, in order to avoid problems due to the use of the same stimuli to assess salience and memory, different stimuli (forms and colors) were used for the two types of tests. A second difference is the paradigm used. Although Jeffrey's hypothesis has usually been tested within the habituation paradigm, the paired-comparison method was used here due to its greater sensitivity under conditions of brief study. There is a third difference. Within the context of Jeffrey's theory, processing of salient features is indicated by the recovery of looking to a novel example of the salient feature. In the present study, salience was related to the speed or efficiency of encoding as indicated by the amount of exposure necessary to yield immediate recognition.

The choice of stimuli is crucial for any study of early visual processing. Although the stimuli that were used in

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the present study avoid problems inherent in Miller's technique (Lasky, 1979), the present use of differing stimuli has its own risks. For example, it is possible that the preference for a dimension is highly dependent upon the particular cues along that dimension. Certainly, if red was the most potent color cue, and a triangle was the least potent form cue, then a preference based on only these cues might indicate that the infant selectively processes the color dimension. This hypothesis might not be borne out if weak yellow cues and strong circular cues were novel on the subsequent recognition test. In the present study, this problem was minimized by assessing dimensional selectivity on the preference test when multiple cues were present within each dimension. The rationale is that general dimensional salience can be estimated by preference for variability (rather than for specific cues) along that dimension (Fantz et al. 1975, p. 304-305).

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Memory for Form and Color

Multidimensional stimuli have typically served in studies of early recognition memory. Simple closed figures or geometric elements differing in form, color, pattern arrangement, or orientation have been familiarized, then altered, to assess the featural changes that infants detect as novel. Differences in methodology, and varying ages of subjects in studies to date make it difficult to characterize the pattern dimensions that infants remember best. Nonetheless, a review of the literature points to some

interesting hypotheses regarding memory for form and color.

In one of the pioneering studies, Saayman, Ames, and Moffett (1964) investigated fixation of familiarized and novel stimuli differing in form, color, or both. They found high novelty responses when both form and color of a novel pattern differed from that of a familiarized pattern. This was not the case when the novel and familiarized stimuli differed on only one of these dimensions. A similar pattern of results was obtained in a more recent study by Welch (1974). Four-month-old infants were shown stimuli which could differ in one, two, or three dimensions (form, color, and pattern arrangement). Increased fixation of the novel stimuli resulted when two or three dimensions, rather than a single dimension, were changed. Specific dimensions or combinations of dimensions did not differentially affect responding. The habituation paradigm has produced similar results. Cohen, Gelber, and Lazar (1971) habituated 4-month-old infants to a red circle. On test trials, male infants' looking times recovered less to stimuli changed on one dimension than to those changed on two dimensions. However, significant recovery was obtained for a change in color or form alone when data from a number of test trials were collapsed. An analysis of the collapsed data indicated significant recovery to form, but not to color. Stronger evidence of infants' discrimination of change involving a single dimension has been obtained by Fagan (1977). Infants of 22 weeks of age were familiarized with a red diamond.

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Stimuli novel in either form or color resulted in significantly longer fixation times in the recognition test. Strauss and Cohen (1980) also report immediate recognition by 5-month-old infants based on discrimination of a single-dimensional change (form, color, size, or orientation).

It appears, therefore, that between 3 and 6 months of age infants become increasingly able to discriminate between familiar and new visual patterns. Early in this period (3 months), the number of dimensions that differentiate the novel and previously exposed stimulus seems to be an important determinant of recognition performance. By about five months, recognition occurs when any single dimension has been changed. At four months, the nature of the changed dimension may be particularly important; the data of Cohen and his associates (Cohen, 1976) suggest that a novel form may be more likely detected than color. Thus, past 4 months of age, there may be differences in memory for form and color dimensions. It may be possible to amplify these differences and relate preferences for dimensions to memory for dimensions.

For this purpose, it can be noted that study time affects the subsequent recognition of particular dimensions (Fagan 1974, 1977). A relatively long study enabled 5-month-old infants to respond to a change in color or form alone; given a shorter study time (30 sec), infants responded only to a change in color. It is questionable,

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however, whether Fagan's study utilized an unambiguous form discrimination. An examination of the stimuli shows them to be differentiated by another feature--orientation.

To assess the speed of encoding of form and color dimensions, the actual time spent looking at the to-be-remembered stimuli can be more informative than the total exposure time. Fagan's subjects looked about 17 sec and 30 sec in the low and high study time groups respectively. Other studies with younger infants have usually obtained somewhat longer fixation times. Welch (1974) reported an average fixation time of 25 sec; these 4-month-old infants did not discriminate a single dimensional change, regardless of dimension. Cohen et al. (1971) reported that male infants had an average total fixation time of 35 sec. These 4-month-old infants responded to a change of either form or color.

In summary, for 20-week-old infants a relatively brief study time of about 20 sec may result in recognition of changes in form but not color; a relatively long study time (30 sec) should allow recognition based on either dimension.

A second variable affecting recognition performance is the length of the retention interval. Fagan (1973) has shown that 5-month-old infants retain information about a photograph of a face up to 2 weeks if the initial exposure is in the order of minutes. However, if the initial study time is quite brief, infants at this same age may fail to recognize a face after a delay of only 40 sec (Cornell,

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1979). Regarding more abstract multidimensional stimuli, there is no clear generalization about delayed retention of stimulus dimensions. Olson (1976) found that 4-month-old infants recognized stimuli varying in form after a 5 min interval. Pancratz and Cohen (1970), however, found 4-month-old infants did not show recovery to novel form-color stimuli after a 5 min delay. Recently, Strauss and Cohen (1980) tested 22-week-old infants in delayed recognition memory for several different dimensions. With separate tests for the stimulus dimensions of form, color, orientation, and size, they found only the first two to be remembered after a 15 min delay. After a longer delay of 24 hr, only form changes were discriminated. In a subsequent study, infants were given two discriminations--one of color, the other of form--which resulted in equivalent novelty scores on an immediate test. Following a 24 hr delay, only form information was remembered.

In summary, highly familiar and meaningful classes of patterns are well-remembered by young infants if initially well-studied. Delayed recognition may be poor if familiarization is brief (Olson, 1976), if the discrimination between the familiar and novel target is subtle (Fagan, 1975) or, as suggested by Jeffrey (1976), the discrimination is on a nonpreferred dimension.

Summary and Rationale

The research on recognition memory for multidimensional stimuli indicates that infants do not initially encode or

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remember all dimensions equally, especially if study time is brief and the retention interval is long. Research on visual selectivity during this same period indicates that changes take place in the pattern dimensions which attract and maintain infants' looking. In both types of visual behavior, indicating preference or memory, it appears that there is selective processing of form and color. In line with Jeffrey (1976), I suggest that the hierarchy of preferences is reflected in the infant's ability to respond to novelty. That is, the relationship between memory and perceptual processes at an early age can be explored by testing the hypothesis that the initial, prefamiliarization probabilities of attending to specific stimulus dimensions influence both the encoding and retention of cues on those dimensions.

In order to test the above hypothesis, 21-week-old infants were assessed individually for preferences along the dimensions of form and color. Immediately following this visual preference pretest, the baby was familiarized with patterns containing both dimensions. Infants were given either a short or a long study period. If preferences influence speed or amount of encoding, then a recognition test after brief study should show high novelty responses only when the preferred dimension is changed.

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II. Method

Subjects

Forty full-term infants were tested in their homes. All families of the infants tested reside in the Edmonton area. Parents volunteered their infants in response to a letter describing the research program; appointments were then made to see the infants at a suitable time. The data gathered from eight babies were discarded, five due to excessive fussiness during testing, and three as a result of failing to meet the criterion of at least one second of looking during any pairing of test patterns. The data from these infants were not included, leaving data from 32 infants for the purposes of analysis. All infants tested were between 20 and 23 weeks old (Mean=21.2 weeks). Equal numbers of girls and boys were assigned to each subgroup within the study.

Apparatus and Materials

All infants included in the study were tested using a portable visual preference apparatus which has been described by Fagan (1970). The major features include (1) two peepholes centered such that observers can clearly monitor the baby's eyes, (2) a rotating stage at the inside rear of the apparatus to present the targets at a distance of 30-35 cm from the infant's eyes, and (3) an interior chamber with a homogenous light-diffusing surface enclosing the visual field of the infant. The apparatus also includes a 4-track Rustrak event recorder wired to finger switches and electronic timers.

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Stimulus materials consisted of two sets of plaques, one set for assessing preferences, the other for assessing memory. The former consisted of two plaques similar to those of Figure 4.17 in Fantz et al. (1975). In the present experiment, the preference stimuli contained colored forms, as illustrated in Figure 1a. The variable color pattern used highly saturated hues from well-separated areas of the spectrum. These values should optimize neural activity (Bornstein, 1978). The variable form pattern used elements of the same color; this hue was of equal saturation but different wavelength than the hues of the variable color stimulus. Pattern elements on both plaques were equated for total amount of contour and thus (by one definition) for complexity (Karmel, 1969). The memory stimuli varied single complex geometric elements along both form and color, as illustrated in Figure 1b. Note that there are two subsets of memory stimuli, and that each subset includes two forms and two colors in different compounds. Stimuli from one subset were arranged to constitute a form recognition test, and stimuli from the other were arranged to constitute a color recognition test. Both subsets were presented to each infant with order counterbalanced across subjects.

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Test Procedure

All infants were tested in their homes at a time when they were awake and attentive. Each was tested while seated on the parent's lap.

The criterion for looking was defined by

superimposition of 75% of the pattern reflection over the pupil of the infant's eye (Fantz, 1966). Recording began with the infant's first look at either of the stimulus plaques, and continued until a click by the event recorder signalled the end of the exposure period. The plaques were then rotated out of the infant's view.

The general procedure included three phases: an initial preference test followed by two separate recognition problems. During the preference test the infant was presented with stimulus plaques paired as illustrated in Figure 1a. The pair was presented for two 10-second trials, plaque positions being reversed on the second trial. Order of presentation was counterbalanced across infants. After a 1-min delay, during which time the infant was out of the testing chamber, the first recognition problem was presented. The infant was familiarized with identical stimulus plaques placed side-by-side on the presentation stage. Looking was recorded until the infant had accumulated the appropriate amount of time. At this point the familiarization period ended and the stimuli were removed. The recognition test immediately began by pairing one of the previously exposed plaques with a novel plaque that contained a change in either form or color. The test pair of stimuli were exposed for two 10-second periods, position of the plaques being reversed on the second presentation. Across infants, all stimuli served equally often as familiar and novel in order to counteract possible stimulus

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preferences that might occur regardless of the familiarization procedures. After the first recognition problem, the infant again spent one minute out of the apparatus. Following this, the baby was given a second recognition problem in the same manner as the first. However, this second problem differed in two aspects. It used the set of stimuli not used in the first problem, and it changed (on the recognition test) the dimension unchanged in the first problem. Thus, each infant received a form recognition problem and a color recognition problem.

Design

Of particular concern in this experiment was whether 21-week-old infants remembered information from a salient dimension (e.g., form) and a nonsalient dimension (e.g., color) given only a very brief study time. Salience was defined by preferential looking in a pretest. For any one infant, his salient dimension was the variable pattern with the longest total fixation time.

The study times used to familiarize the babies with the patterns to be remembered were estimated from the literature reviewed above; 20 sec is probably short enough to allow encoding of only one dimension, and 30 sec may be long enough for two.

Two groups of 16 infants were tested. Both groups were given the visual preference tests as outlined in the previous section. One group accumulated 20 sec of study time during the familiarization phase of the recognition

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problems. The second group accumulated 30 sec.

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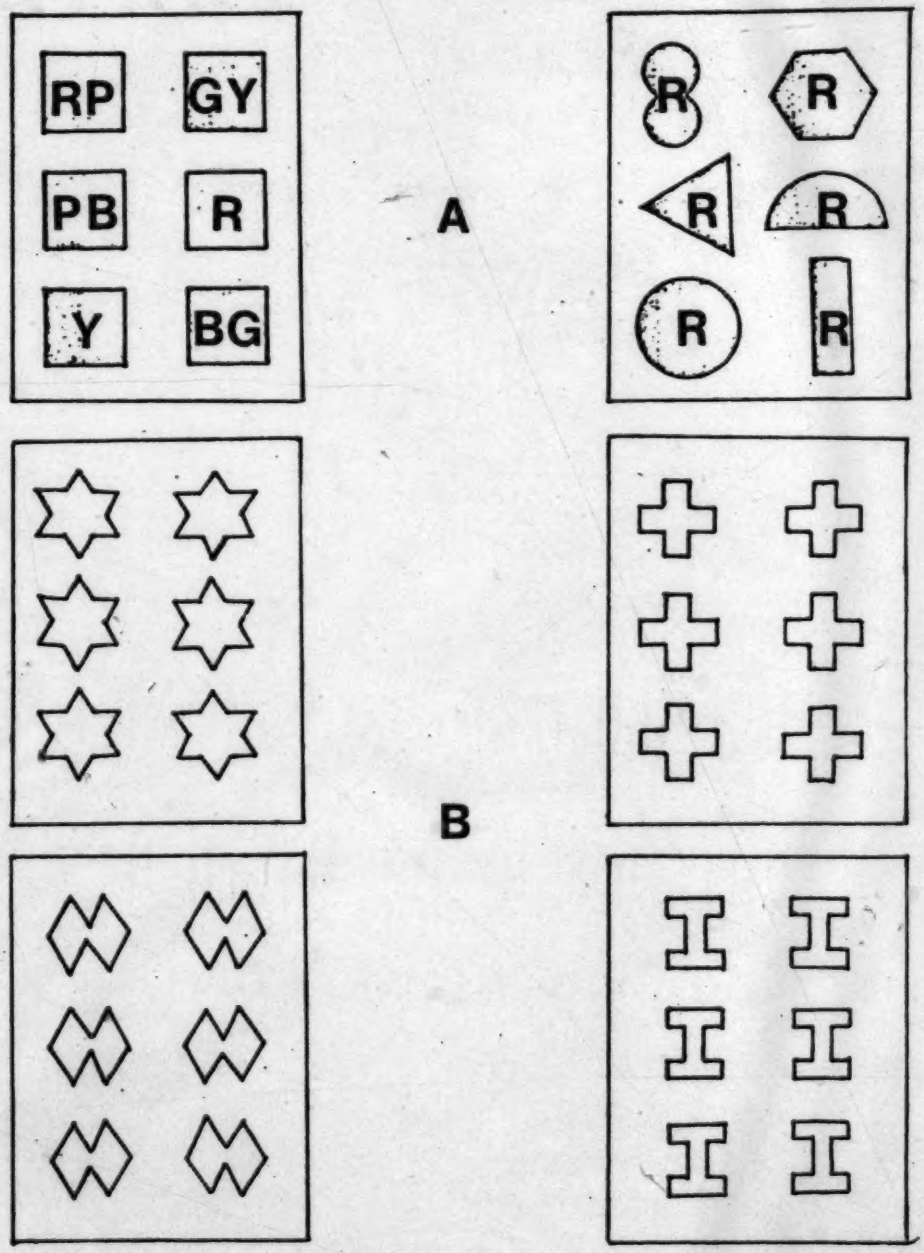

Figure 1. A. Preference stimuli: Same Form--Variable Color; Same Color--Variable Form. B. Recognition stimuli: One set consisted of stars or crosses; the other set consisted of bowties or I's.

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III. Results

As outlined above, the visual preference pretests provided an operational definition of dimensional salience. For each infant, the amount of looking to the multiple form was divided by the amount of looking to both patterns, and expressed as a percentage. This percentage constituted the basis for defining whether a recognition test assessed memory for a salient or nonsalient dimension. For example, an infant showing more than 50 percent looking to multiple form would have the form recognition problem assigned as salient dimension changed. The color problem would then constitute a nonsalient change. For 30 of the 32 infants tested, the above pattern of preferences was found--that is, the form problem was assigned as salient. For the infants tested the mean percentage of looking time to the multiple form pattern was 72.1.

The percentage of total fixation to the novel test stimulus constituted the dependent measure on the recognition problems. Prior to examining group differences, preliminary analyses were done to determine whether the factors of sex of subject and test order produced reliable differences in test performance. As they did not, data were collapsed across these factors. Thus, the two remaining factors of interest were study time (20 and 30 sec), and dimension (salient and nonsalient). The latter was within subjects. A repeated-measures ANOVA of the novelty scores indicated that study time had no significant effect on

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response to novelty either on its own or in interaction with dimension, *F*s (1,30) < 1. However, a significant main effect due to the latter factor (dimension) was found: Change of the salient dimension (form) resulted in a greater novelty response, *F* (1,30) = 4.41, *p* < .05.

The failure to obtain an interaction between study time and dimension on the ANOVA contradicts the initial prediction that the two dimensions should show differential speed or efficiency of encoding. However, the between-groups analyses are not the results of major interest since they are less sensitive than within-groups tests to the difference between recognition and non-recognition.

The major interest of the study was the level of recognition performance for the four conditions defined as to whether study time was 20 or 30 sec, and whether dimension was salient or nonsalient. Accordingly, novelty scores were averaged for infants within each of the above treatment conditions. The resulting means are listed in Table 1 along with the *t* value for each. These values represent tests of whether the mean percentage of fixation time to novelty departed reliably from a chance value of 50 percent. A reliable discriminative response to novelty thus is the basis for inferring recognition. Reliable recognition was found in all instances except when the baby was given a brief study period (20 sec) and was subsequently tested for recognition along a nonsalient dimension. It should be noted that the probability levels listed in Table 1 are for

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one-tailed *t* tests as the infants are expected at this age to look relatively more at a novel stimulus.

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Table 1

Percentage of Fixation Time to the Novel Stimulus During Recognition Tests

Dimension Relevant	Length of Familiarization (sec)	Novel Fixation (%)	t
Salient	20	63.6	3.13***
Nonsalient	20	53.1	0.80
Salient	30	65.4	2.74**
Nonsalient	30	59.3	2.06*

Note. Each entry represents the mean value for 16 infants.

* < .05

**p < .01

***p < .005

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IV. Discussion

In summary, 21-week-old infants looked longer at a pattern of variable shapes than at a pattern of variable bright, saturated hues, when given an opportunity to view both. In addition, these infants looked longer at a novel stimulus that involved a change along this salient dimension (form). This was true regardless of the length of the study opportunity initially given to the infants. An increase in the amount of study time did not lead to a significant increase in the amount of looking to a novel salient cue.

The interpretation of group differences in recognition performance is best done with reference to the *t*-tests since these values indicate a significant response to novelty. The *t* values indicate that infants did not show reliable recognition in one condition only. When infants had only 20 sec to study a pattern, they were subsequently unable to discriminate a novel nonsalient cue. That is, they looked about equally at the previously exposed and changed pattern. On the other hand, when recognition required the infants to discriminate a change along a salient dimension, again given only 20 sec of study, they looked at the novel pattern at a level significantly higher than chance. Those infants given 30 sec of study showed reliable recognition of either a salient or a nonsalient cue.

The results of the recognition analyses can be summarized as following. Overall amount of looking to a novel salient cue is likely to be greater than to a novel

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nonsalient cue, regardless of length of familiarization. When looking to novelty is compared to a chance value of 50 percent, length of familiarization is important in predicting which cue(s) will be recognized. In particular, 20 sec of study is more likely to produce significant looking to a novel form cue than to a novel color cue. By 4-5 months of age, then, infants' tendency is to prefer form and to remember form better than color. This suggests that infants' visual preferences may be related to a further aspect of early development--visual recognition memory.

The pattern of preferences obtained in this study agrees with the earlier findings of Fantz et al. (1975), in that variations in form attracted infants' looking to a greater degree than did variations in color. The obtained pattern of preferences is also an indication that factors such as saturation and amount of contour, while adequately accounting for preferences between simple visual stimuli, seem to be less clearly predictive of infants' preferences for more complex aspects of patterning (Haith, 1978).

In most theories of perceptual learning a preference for form variation seems to have high ecological validity; shape differences provide the infant with information about classes of objects, whereas other stimulus variations such as color, size, and orientation vary across exemplars (Strauss & Cohen, 1980). Rosch's investigations (1978) have indicated that form information is highly important in determining the basic level of object classification.

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Simiarity judgments and recognition of form seem to be critical in identifying basic objects (e.g., chair, car) as opposed to superordinate classes (e.g., furniture) or subordinate class objects (e.g., stock car). In infant perceptual development, visual selectivities such as that for form have been suggested to promote learning the invariant properties of objects. Ruff (1980) notes that variations such as color, which change across instances of objects, may not be attended by the baby and may help to focus attention on the object's relatively more invariant structure, such as its form.

These conceptualizations are related to the adaptive role of visual preferences. However, the same arguments could be extended to explain why form is better remembered. Within a serial processing model of infant recognition memory, processing form before color would be based on general propensities to extract the most useful information first. One possible operationalization of usefulness of information would be the categorization measures used by Rosch (1978). High-order information about objects such as their form is useful in that it can direct processing towards low-order, more detailed properties of those objects. Furthermore, such high-order information appears to be available very early in visual processing (Rosch, 1978). Within the present context, temporally ordered processing of stimulus attributes implies that brief presentations should more likely result in memory for the more useful

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information--form.

An alternate explanation for the high percentage of time spent looking at the variable forms considers the processing requirements of different stimulus attributes. Simply put, encoding of form may require a series of fixations; encoding of color may not require extensive scanning. This would point to an unequal distribution of processing effort. In the present context, the amount of time processing form and color dimensions may not have been the crucial variable; processing effort may have been important. It may be that the infants encoded the form variants with more effort. On the recognition tests, it is assumed that the features requiring active processing would have representation in working memory (Crowder, 1976; Wagner, 1978). Specifically, if an initial stimulus presentation resulted in more effort in the encoding of form than color, subsequent discriminations between the familiar and a novel stimulus more likely would be made on the basis of form. Neither of the above models is unequivocally supported by the present data. Rather, the data serve to indicate that concepts such as serial processing and processing effort may be useful in developing a more complete theoretical account of infant recognition memory.

An important point in this regard is that distinguishing between such alternative accounts may be possible, if difficult, with adults; with infants it may be much more difficult. As has been noted, the possibility of

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obtaining small, but stable differences on a particular measure (e.g., reaction time) is important if distinctions such as the above are to be made. Infant behavior such as amount of looking to a novel stimulus usually does not meet these specifications. A finer analysis of the infant's visual behavior (e.g., eye movements) during recognition memory tasks may reveal reliable differences of importance for distinguishing between alternative accounts of underlying processes.

The present findings are an indication that speed of encoding has a weak but suggestive correlation with salience. Another promising index of the relationship between salience and memory is duration of retention, as indicated by Strauss and Cohen (1980). Although they discounted differences in cue salience as accounting for differences in retention of form and color information, it is unclear whether their operationalization of salience was adequate. That is, equating one form and one color cue for salience may not be the same as equating general dimensional salience. The latter, as defined by the procedures used in the present study, may predict which cues will be retained longer. Again, should such results be obtained in future research, process explanations should be sought.

In conclusion, the present findings contribute to the small body of evidence that infants, like adults, do not remember all things equally well. In particular, general visual preferences for a dimension seem to indicate what is

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likely to be remembered. The processes that underlie this differential encoding can be interpreted either within a model of a serial processor or a model in which memory is a function of encoding effort. In conclusion, it appears necessary that future research on infant recognition memory attempt to understand the bases and processes that underlie selectivity in early memory.

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References

Berlyne, D. E. Conflict, arousal, and curiosity. New York: McGraw-Hill, 1960.

Bornstein, M. H. Visual behavior of the young infant: Relationships between chromatic and spatial perception and the activity of underlying brain mechanisms. Journal of Experimental Child Psychology, 1978, 26, 174-192.

Bronson, G. W. The postnatal growth of visual capacity. Child Development, 1974, 45, 873-890.

Cohen, L. B. Habituation of infant visual attention. In T. J. Tighe & R. N. Leaton (Eds.), Habituation: Perspectives from child development, animal behavior, and neurophysiology. Hillsdale, N.J.: Erlbaum, 1976.

Cohen, L. B., DeLoache, J. S., & Strauss, M. S. Infant visual perception. In J. D. Osofsky (Ed.), The handbook of infant development. New York: Wiley, 1979.

Cohen, L. B., Gelber, E. R., & Lazar, M. A. Infant habituation and generalization to differing degrees of stimulus novelty. Journal of Experimental Child Psychology, 1971, 11 , 379-389.

Cornell, E. H. Infants' recognition memory, forgetting, and savings. Journal of Experimental Child Psychology, 1979, 28, 359-374.

Crowder, R. G. Principles of learning and memory. Hillsdale, N.J.: Erlbaum, 1976.

Fagan, J. F. Memory in the infant. Journal of Experimental Child Psychology, 1970, 9, 217-226.

University of Alberta

Fagan, J. F. Infant's delayed recognition memory and forgetting. Journal of Experimental Child Psychology, 1973, 16, 424-450.

Fagan, J. F. Infant recognition memory: The effects of length of familiarization and type of discrimination task. Child Development, 1974, 45, 351-356.

Fagan, J. F. Infant recognition memory as a present and future index of cognitive abilities. In N. R. Ellis (Ed.), Aberrant development in infancy. Hillsdale, N. J.: Erlbaum, 1975.

Fagan, J. F. An attention model of infant recognition. Child Development, 1977, 48, 345-359. (a)

Fagan, J. F. Infant recognition memory: Studies in forgetting. Child Development, 1977, 48, 68-78.

Fantz, R. L. Pattern discrimination and selective attention as determinants of perceptual development from birth. In A. Kidd & J. Rivoire (Eds.), Perceptual development in children. New York: International Universities Press, 1966.

Fantz, R. L., & Fagan, J. F. Visual attention to size and number of pattern details by term and preterm infants during the first six months. Child Development, 1975, 16, 3-18.

Fantz, R. L., Fagan, J. F., & Miranda, S. Early visual selectivity. In L. B. Cohen & P. Salapatek (Eds.), Infant perception: From sensation to cognition: Basic visual processes (Vol. 1). New York: Academic Press,

University of Alberta

1975.

Fantz, R. L., & Nevis, S. Pattern preference and perceptual-cognitive development in early infancy. Merrill-Palmer Quarterly, 1967, 13, 77-108.

Friedman, S. Infant habituation: Process, problems and possibilities. In N. R. Ellis (Ed.), Aberrant development in infancy. Hillsdale, N.J.: Erlbaum, 1975.

Greenberg, D. J. Accelerating visual complexity levels in the human infant. Child Development, 1971, 42, 905-918.

Haith, M. M. Visual competence in early infancy. In R. Held, H. W. Leibowitz, & H. L. Teuber (Eds.), Handbook of sensory physiology (Vol. 8). New York: Springer-Verlag, 1978.

Haith, M. M., Kessen, W., & Collins, D. Response of the human infant to level of complexity of intermittant visual movement. Journal of Experimental Child Psychology, 1969, 7, 52-69.

Jeffrey, W. E. Habituation as a mechanism for perceptual development. In T. J. Tighe & R. N. Leaton (Eds.), Habituation: Perspectives from child development, animal behavior, and neurophysiology. Hillsdale, N.J.: Erlbaum, 1976.

Karmel, B. Z. The effect of age, complexity, and amount of contour on pattern preferences in human infants. Journal of Experimental Child Psychology, 1969, 7, 339-354.

Karmel, B. Z., & Maisel, E. B. A neuronal activity model for infant visual attention. In L.B. Cohen & P. Salapatek

University of Alberta

(Eds.), Infant perception: From sensation to cognition: Basic visual processes (Vol. 1). New York: Academic Press, 1975.

Kessen, W., Haith, M. M., & P. Salapatek. Human infancy: A bibliography and guide. In H. P. Mussen (Ed.), Carmichael's manual of child psychology (Vol. 1). New York: Wiley, 1970.

Lasky, R. E. Serial habituation or regression to the mean? Child Development, 1979, 50, 568-570.

Miller, D. Visual habituation in the human infant. Child Development, 1972, 43, 481-493.

Miller, D. J., Ryan, E. B., Sinnott, J. P., & Wilson, M. A. Serial habituation in two-, three-, and four-month-old infants. Child Development, 1976, 47, 341-349.

Olson, G. M. An information-processing analysis of visual memory and habituation in infants. In T. J. Tighe & R. N. Leaton (Eds.), Habituation: Perspectives from child development, animal behavior, and neurophysiology. Hillsdale, N.J.: Erlbaum, 1976.

Pancratz, C. N., & Cohen, L. B. Recovery of habituation in infants. Journal of Experimental Child Psychology, 1970, 9, 208-216.

Rosch, E. Principles of categorization. In E. Rosch & B. B. Lloyd (Eds.), Cognition and categorization. Hillsdale, N.J.: Erlbaum, 1978.

Ruff, H. A. The development of perception and recognition of objects. Child Development, 1980, 51, 981-992.

University of Alberta

Saayman, G., Ames, E. W., & Moffett, A. Response to novelty as an indicator of visual discrimination in the human infant. Journal of Experimental Child Psychology, 1964, 1, 189-198.

Strauss, M. S., & Cohen, L. B. Infant immediate and delayed memory for perceptual dimensions. Presented at the 1980 meeting of the International Conference on Infancy Studies, New Haven, Connecticut.

Wagner, A. R. Expectancies and the priming of STM. In S. H. Hulse, H. Fowler, & W. K. Honig (Eds.), Cognitive processes in animal behavior. Hillsdale, N.J.: Erlbaum, 1978.

Welch, M. J. Infant's visual attention to varying degrees of novelty. Child Development, 1974, 45, 344-350.

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